CLAIMS

What is claimed is:

1. An optical node for an optical network transporting an optical datastream, the node comprising:

at least one port for optically coupling the node to at least one neighboring node;

a fault restoration element to adjust the operation of the node in response to a fault;

at least one optical sensor for measuring a first set of optical characteristics of the optical datastream at the node;

a signal sensor configured to receive a second set of optical characteristics of the optical datastream from an upstream optical device; and

a local controller configured to activate the fault restoration element if the first and second set of optical characteristics have values corresponding to a potential fault requiring activation of the fault restoration element.

2. The node of Claim 1, wherein said controller is a microprocessor having a software program residing on the microprocessor, the software program including a list of possible faults and corresponding restoration actions as a function of the first and second set of optical characteristics.

3. The node of Claim 2, wherein said software program records the result of the restoration instance and communicates the result of the restoration instance to the optical network.

4. The node of Claim 2, wherein said software program communicates a message alerting other nodes of optical network of an upcoming restoration instance prior to the restoration instance.

5. The node of Claim 2, wherein said software program includes a list of internal components likely to have failed as a function of said first and second set of optical characteristics, said software program preparing a list of components likely to have failed for each restoration instance.

6. The node of Claim 1, wherein said restoration element is selected from the group consisting of: a line switcher, a redundant electrical element, and a redundant electro-optical element.

7. The node of Claim 1, wherein said upstream device is an optical spectrum analyzer.

8. The node of Claim 1, wherein said upstream device is an upstream node having a least one optical sensor residing in the upstream node.

9. The node of Claim 8, wherein the signal sensor is an optical receiver for receiving status messages via an optical channel, whereby the upstream node communicates said second set of optical characteristics as a status message via an optical fiber.

10. An optical node for an optical network, the node comprising:

at least one input port for receiving an optical datastream having a plurality of channels;

a plurality of output ports for communicating the data stream to at least one other node via at least one optical fiber link;

a line switcher arranged to select an optical pathway for the data stream between two of the ports of the node in response to a line switch command;

a demultiplexing stage arranged to select at least one channel from said datastream, said stage including at least one redundant electro-optic element configured to replace a defective electro-optic element of said stage in response to an equipment switch command;

at least one optical sensor configured to measure a first set of optical characteristics of the channels;

a signal sensor for receiving data from an upstream device on a second set of optical characteristics of the channels upstream of the node; and

a local controller configured to generate the switch commands, the local controller comparing said first and said second set of optical characteristics to detect a loss of signal in one or more of the channels, the controller initiating a line switch to isolate a line fault or an equipment switch to isolate an equipment fault.

11. The node of Claim 10, wherein said local controller comprises a micro-processor having a software program residing on said micro-processor for generating the line switch commands and the equipment switch commands, the software program comparing said first and said second set of optical characteristics against a problem list to

determine if a fault has occurred requiring the controller to initiate a line switch or an equipment switch.

12. The node of Claim 11, wherein said software program includes a fault detector detecting potential faults as a function of the problem list, a line switch engine coupled to the fault detector for activating the line switcher in response to instructions of the fault detector, and an equipment switch engine coupled to the fault detector for activating the redundant electro-optic element in the node in response to instructions from the fault detector.

13. The node of Claim 10, wherein the upstream device is an optical spectrum analyzer.

14. The node of Claim 10, wherein the upstream device is a neighboring node.

15. An optical node for an optical network, the node comprising:

a plurality of ports for receiving an optical data stream having a plurality of optical channels and communicating the data stream to at least one other node;

at least one fault restoration element to adjust the operation of the node in response to a fault;

at least one optical sensor configured to measure a first set of optical characteristics of the channels in the node;

at least one transceiver for communicating optical network status information via an inter-node optical communications channel with a neighboring node, the optical

network status information including a second set of optical characteristics of the optical channels determined by sensors residing in at least one other node of the optical network;

a local controller configured to active the at least one fault restoration element if the first and second set of optical characteristics have values corresponding to a potential fault requiring activation of the fault restoration element.

16. The node of Claim 15, wherein the optical network status information includes the publication of a planned line switch or equipment switch in another node and the local controller is configured to interpret the planned line switch or equipment switch as a request to not initiate a local line switch command or an equipment switch command during a time period corresponding to the planned line switch or equipment switch.

17. The node of Claim 15, wherein the optical network status information includes a channel map of active channels throughout the optical network.

18. The node of Claim 15, wherein said at least one restoration element includes:

a line switcher arranged to select an optical pathway for the data stream between two of the ports of the node in response to a line switch command; and

a demultiplexing stage arranged to select at least one channel from said data stream, said stage including at least one redundant electro-optic element configured to replace a defective electro-optic element of said stage in response to an equipment switch command;

wherein the local controller is configured to generate the switch commands, the local controller comparing said first and said second set of optical characteristics to detect

a loss of signal in one or more of the channels, the controller initiating a line switch to isolate a line fault or an equipment switch to isolate an equipment fault

19. An optical node for a wavelength division multiplexing optical network having an optical datastream with a plurality of optical channels, the node comprising:

a transport module, including:

a first primary fiber interface port;

a second primary fiber interface port;

a first secondary fiber port;

a second secondary fiber port;

at least one input having an optical sensor;

at least one output having an optical sensor;

at least one transceiver for communicating network channel status information with at least one neighboring node via an inter-node optical communications channel; and

a line switcher arranged to select an optical pathway between two of said ports in response to a line switch command;

a channel selection module optically coupled to said transport module, said channel selection module including:

a first filter stage containing a demultiplexor element arranged to select a band of channels from said transport module;

a second filter stage coupled to the first stage and arranged to select one of the channels of said band of channels;

at least one redundant electro-optic element configured to replace a defective electro-optic element of said first stage in response to an equipment switch command; and

at least one optical sensor coupled to the second stage;

a tributary module coupled to transport module, said multiplex module containing at least one transponder for linking data from a selected optical channel to at least one channel of an external tributary network ; and

a control module configured to generate the switch commands, wherein the control module correlates the optical characteristics of the channels measured at the node with the channel status information received from at least one other node to determine if the node should initiate a line switch or an equipment switch.

20. A wavelength division multiplexing optical network, comprising:

a first node containing a first optical sensor, a first transceiver for receiving and transmitting data on an inter-node channel, and a first local microprocessor for controlling a first line switcher and a first set of redundant electrical elements, the first local microprocessor transmitting a first status report on the optical characteristics of the channels in said first node via said first transceiver;

a second node containing a second optical sensor, a second transceiver for receiving and transmitting data on the inter-node channel, and a second local microprocessor for controlling a second line switcher and a second set of redundant electrical elements, the second local microprocessor transmitting a second status report on the optical characteristics of the channels in said second node via said second transceiver;

a primary optical fiber line linking said first and said second nodes; and

a protection optical fiber line linking said first and said second nodes;

wherein each local microprocessor determines whether to perform a line switch or an equipment switch as a function of the optical power characteristics of the local node correlated with the status reports from the other nodes of the optical network via the inter-node channel.

21. A wavelength division multiplexing optical ring network, comprising:

a first node containing a first optical sensor, a first transceiver for receiving and transmitting data on a first inter-node channel, and a first local microprocessor for controlling a first line switcher and a first set of redundant electrical elements, the first local microprocessor transmitting status reports on the optical characteristics of the channels in said first node via said first transceiver;

a second node containing a second optical sensor, a second transceiver for receiving and transmitting data on the first inter-node channel, a third transceiver for receiving and transmitting data on a second inter-node channel, and a second local microprocessor for controlling a second line switcher and a second set of redundant electrical elements, the second local microprocessor transmitting status reports on the optical characteristics of the channels in said second node via said second transceiver;

a third node containing a third optical sensor, a fourth transceiver for receiving and transmitting data on the second inter-node channel, and a third local microprocessor for controlling a second line switcher and a third set of redundant electrical elements, the third local microprocessor transmitting status reports on the optical characteristics of the channels in said third node via said fourth transceiver;

a first primary optical fiber line linking said first and said second nodes;

a first protection optical fiber line linking said first and said second nodes;

a second primary optical fiber line linking said second and third nodes;

a second protection optical fiber line linking said second and third nodes; and

at least one additional optical element linking said nodes into an optical ring;

wherein each of the microprocessors determines whether to perform a line switch or an equipment switch in the node which it resides as a function of the optical characteristics sensed at the local node and the status reports received from the other nodes.

22. A method of fault detection and isolation in a node of an optical network having a datastream with a plurality of optical channels, the network including a plurality of nodes coupled to each neighboring node, each node having at least one local optical sensor, each node having at least one optical transceiver for communicating status reports to each neighboring node that it is optically coupled to, and each node having a local controller for controlling a local line switcher residing in the node, the method comprising the steps of:

sensing a loss in signal from a neighboring node via the local optical sensor;

monitoring the transceiver to determine if the neighboring node is communicating status reports to the node; and

initiating a line switch to redirect traffic to an alternate optical path to restore data traffic if there is a loss in signal from the neighboring node and status reports are not being receiving from the neighboring node.

23. The method of Claim 22, further comprising the steps of:

waiting a preselected period of time to verify a loss of signal; and

initiating a line switch in the node unless a status report is received within the preselected time.

24. A method of fault detection and isolation in a node of an optical network having an optical datastream with a plurality of channels, the network including a plurality of nodes optically coupled to each neighboring node, each node having at least one local optical sensor, at least one transceiver for communicating data to each neighboring node that it is coupled to, and a local controller for controlling redundant elements residing in the node, the method comprising the steps of:

sensing a first set of optical characteristics of the optical channels traversing the node;

receiving status reports that include a second set of optical characteristics of the optical channels measured by at least one sensor in another node of the network;

comparing the first and second set of optical characteristics;

determining if one or more optical channels are being dropped in the node; and

initiating an equipment switch in the local node to restore the dropped traffic.

25. The method of Claim 24, wherein the second set of optical characteristics are measured upstream of the node.

26. The method of Claim 25, wherein each upstream node includes optical sensors and the second set of optical characteristics is measured using the optical sensors of the upstream nodes.

27. The method of Claim 26, wherein the second set of optical characteristics include a channel map of active channels in the network.

28. A method of fault detection and isolation in a node of a wavelength division multiplexing optical network comprising a plurality of nodes coupled to each neighboring node by at least two fibers, each node having at least one local optical sensor for each channel linked to a local tributary network, at least one transceiver for communicating data to each neighboring node that it is coupled to, and a local microprocessor for controlling a local line switcher and redundant demultiplexing elements residing in the node, the method comprising the steps of:

sensing the optical power characteristics of all of the optical channels traversing the node;

sensing the optical power characteristics of each channel linked to the local tributary network;

receiving reports on the optical characteristics of the optical channels in neighboring upstream nodes;

updating a status list of measured channel characteristics in the node and in neighboring upstream nodes; and

determining if the power level of one of the channels drops below a predetermined level;

waiting a preselected period of time to receive a status update from the upstream nodes; and

selecting an equipment switch decision if a correlation of the channel power distribution between the node and upstream nodes indicates a likelihood that a failure has occurred in an electro-optic element in the node;

notifying downstream nodes that an equipment switch will be made; and

activating redundant electro-optic elements in the node.

29. A method of fault detection and isolation in a node of a wavelength division multiplexing optical network comprising a plurality of nodes coupled to each neighboring node by at least two fibers, each node having at least one local optical power detector for measuring the power of each channel linked to a local tributary network, at least one transceiver for communicating data to each neighboring node that it is coupled to, and a local microprocessor for controlling a local line switcher and redundant demultiplexing elements residing in the node, the method comprising the steps of:

measuring the optical power level of all of the optical channels traversing the node;

measuring the optical power level of at each channel linked to the local tributary network;

receiving reports on the optical characteristics of the optical channels in neighboring upstream nodes;

updating a status list of measured channel characteristics in the node and in neighboring upstream nodes; and

determining if the power level of one of the channels drops below a predetermined level;

waiting a preselected period of time to receive a status update from the upstream nodes; and

selecting an equipment switch decision if a correlation of the channel power distribution between the node and upstream nodes indicates a likelihood that a failure has occurred in an electro-optic element in the node;

notifying downstream nodes that an equipment switch will be made; and

activating redundant electro-optic elements in the node.

30. he method of Claim 29, wherein if a correlation of the channel power distribution between the node and upstream nodes that a failure is unlikely to have occurred in the node a signal is transmitted to the upstream node requesting an equipment switch.

31. The method of Claim 30, further comprising the steps of: determining if the equipment switch restored power to the dropped channels and notifying neighboring channels of the result of the equipment switch.

32. The method of Claim 30, further comprising the steps of: forming a list of components likely to have failed as function of the dropped channels and the result of the equipment switch; and displaying information indicative of components likely to have failed.

33. A method of fault detection and isolation in a node of an wavelength division multiplexing optical network, the node having at least one local optical sensor for each channel linked to a local tributary network and a local microprocessor coupled

to the node for controlling a redundant demultiplexing element of the node, the method comprising the steps of:

measuring the power level of each channel linked to the local tributary network;

measuring the power levels of a plurality of channels upstream of the node;

comparing the power level of each channel linked to the local tributary network with the power levels of the channel upstream of the node; and

initiating an equipment switch command sequence if a channel is dropped in the node.

34. The method of Claim 33, wherein the equipment switch command sequence includes the steps of: notifying downstream nodes than an equipment switch will be made; and activating redundant electro-optic elements in the node.

35. A method of coordinating the action of the nodes of optical network to perform a fault detection and isolation network function, each node of the network system status reports between optical network nodes fault detection and isolation in an each node including at least one local optical sensor for measuring optical characteristics of the datastream at the local node, at least one transceiver for communicating data to each neighboring node that it is coupled to via a fiber optic link, and each node having a local controller for controlling at least one local restoration element, the method comprising the steps of:

sensing a first set of optical characteristics of the datastream at a first node;

updating a channel map of active channels at the first node;

communicating the updated channel map to a neighboring second node via the fiber optic link;

sensing a second set of optical characteristics of the datastream at the second node; and

comparing the second set of optical characteristics to the channel map to determine if a fault has occurred requiring that the controller at the second node to perform activate a restoration element.

36. A method of fault detection and isolation in an optical network having a plurality of optical nodes, each node including at least one local optical sensor for measuring optical characteristics of the datastream at the local node, at least one transceiver for communicating data to each neighboring node that it is coupled to via a fiber optic link, and each node having a local controller for controlling at least one local restoration element, the method comprising the steps of:

sensing a set of optical characteristics of the datastream at each node;

updating a channel map of active channels at each node of the optical network; and

communicating the updated channel map to the nodes via the fiber optic link;

wherein each local controller compares the optical characteristics measured at the local node to the channel map to determine if a fault has occurred requiring that the local controller activate a restoration element.